UNITED STATES
DEPARTMENT OF AGRICULTURE
DEPARTMENT CIRCULAR 405

Washington, D. C.

Issued, January, 1927
Revised, January, 1930

THE DOMESTIC OIL BURNER

By

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UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1930

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By Arthur H. Senner, *Associate Mechanical Engineer, Division of Agricultural Engineering, Bureau of Public Roads*[2]

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INTRODUCTION

MANY TYPES OF OIL BURNERS designed especially for home-heating purposes have been placed on the market within the last few years. The new method of heating appeals to many home owners because of the relief from uncertainties of coal supply, from furnace attendance, dirt, etc. The possibility of automatically regulating the heat is another attractive feature.

To meet the demand of prospective purchasers of this type of heating equipment for reliable information the United States Department of Agriculture has tested a number of oil burners of different design and has prepared this bulletin, based on the results of the tests, in which an attempt has been made to give the information necessary for the home owner to make his own selection of an oil burner.

The tests conducted by the department, and a study of many installations, indicate the character of performance that may be expected of the several types of burners, the adaptability of existing heating plants, and the facts concerning oil-fuel supplies and operation costs.

OIL FUELS

ORIGIN

Some knowledge of the fuel oils employed is essential to the intelligent operation of domestic oil burners. Fuels are derived from

[1] Because of the keen interest of the officials of the Bureau of Home Economics in the subject of this circular, a financial contribution was made by that bureau toward the research work involved and the preparation of the results for publication.

[2] The writer acknowledges the valuable assistance of E. W. Hunter, associate valuation engineer, in the preparation of this bulletin.

crude oils obtained from different fields and vary considerably. They are divided into two main groups, paraffin base oils and asphaltic base oils. The paraffin oils vary in color from a dark green to a light amber and are found principally in the Appalachian regions and midcontinent fields. The asphaltic types are the heavier oils and are found in large quantities in California and the Gulf-coast regions. They are darker in color than the paraffin oils and vary from a red-brown to black. A great many products are derived from crude oil by slowly heating it and collecting the products given off. At the lower temperatures gasoline and kerosene are obtained, while at higher temperatures fuel oil, lubricating oils, and other products are given off, each within a fixed range of temperature. The number of products obtained depends upon the market demand. Figure 1 shows a typical distillation of a paraffin oil and an asphaltic oil in which fuel oil was obtained. Either distillation might have been varied to give a different range of products. In the case of the asphaltic oil, for example, the residue after the gasoline and kerosene

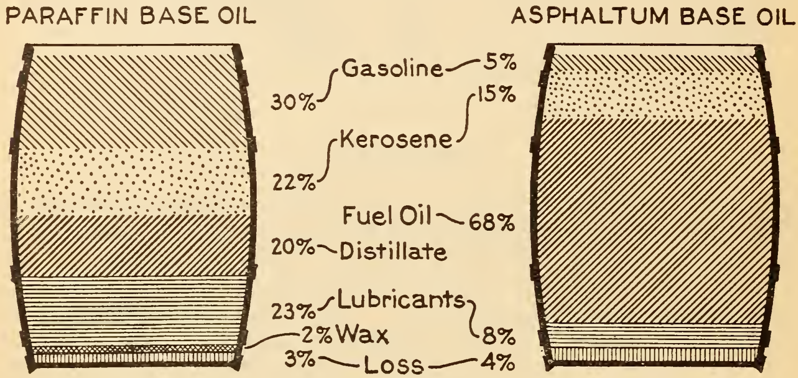

FIGURE 1.—Typical example of products resulting from ordinary refining of paraffin asphaltum base oils (cracking process not used)

had been driven off might have been used for road-building purposes or further distilled for a number of grades of lubricants without producing any fuel oil.

Any portion of the distillate after the gasoline and kerosene are driven off may be used for heating purposes provided it will flow readily in cold weather, but it is the lighter oils immediately following the kerosene that are the most suitable for domestic oil burners.

DISTINGUISHING CHARACTERISTICS

Oil fuels are sometimes distinguished one from another by their density or heaviness, commonly referred to as the "gravity." This characteristic is determined by the use of a hydrometer similar in principle to that used in testing storage batteries but with a different scale.

Hydrometers used for oil testing are graduated with either the Baumé scale or the A. P. I. (American Petroleum Institute) scale. Both of these scales are arbitrary and differ but little from each

other. They are identical at the 10° mark which corresponds to a specific gravity of 1.00 or the density of water.

The A. P. I. scale hydrometer is now generally accepted as the standard instrument for determining the gravity of oils. From Table 1 specific gravities corresponding to A. P. I. or Baumé degrees may be obtained. The last column in this table gives the weight in pounds per gallon. It will be noted that the lower A. P. I. or Baumé gravities correspond to the heavier oils and vice versa.

TABLE 1.—*Comparison of A. P. I. and Baumé scales with specific gravity and weight in pounds per gallon*[1]

A. P. I. gravity	Baumé gravity	Specific gravity	Weight (pounds per gallon)
10	10.0	1.0000	8.328
20	19.9	.9340	7.778
30	29.8	.8762	7.296
40	39.7	.8251	6.870
50	49.6	.7796	6.490
60	59.5	.7389	6.151
70	69.4	.7022	5.845
80	79.3	.6690	5.568
90	89.2	.6388	5.316
100	99.1	.6112	5.086

[1] More complete tables may be found in the following: United States Department of Commerce, Bureau of Standards, National Standard Petroleum Oil Tables. U. S. Dept. Com., Bur. Standards Circ. 154, 175 pp., 1924. This circular may be obtained at 30 cents per copy from the Superintendent of Documents, Government Printing Office, Washington, D. C.

The classification of oils according to gravity came about, undoubtedly, from the comparative ease of determining this property. However, gravity is of no real value as an indicator of the volatility or viscosity of fuel oil. Oil fuels are now commercially known as domestic fuel oils, No. 1, No. 2, and No. 3; and industrial fuel oils, No. 4, No. 5, and No. 6. Sometimes the fuels are referred to as light, medium, and heavy domestic oils; and light, medium, and heavy industrial oils. For most of the domestic burners of the present day, the manufacturers recommend fuel oil No. 3, while many burn either No. 1 or No. 2 fuel. The No. 4, a light industrial oil, is recommended for a small number of domestic burners now manufactured. The characteristics of the oils identified by the numbers 1 to 6 can not be stated very well in nontechnical language but it is perhaps sufficient to say that the oils identified by successively higher numbers may have a correspondingly higher flash point, contain more water and solid matter, and be less volatile and more viscous. Also the oils identified by the higher numbers generally are cheaper and contain more heat units per gallon. Generally speaking, the industrial fuel oils are too viscous for use in most domestic oil burners. Such oils are generally preheated, after which they are more readily atomized. Preheating equipment has not been resorted to in the typical domestic equipment of the present time.

SPECIFICATIONS[3]

Oil burners which have the approval of the National Board of Fire Underwriters will burn with a minimum hazard oil fuels of certain

[3] Commercial standard specifications for domestic and industrial fuel oils are obtainable from the Division of Trade Standards, Bureau of Standards, Washington, D. C.

gravity, but this does not necessarily mean that the oil specified is that most economical to burn. The important factors to keep in mind in an examination of an oil fuel are: Flash and fire points, volatility, viscosity, percentage of water, solid matter, sulphur content, and the heating value of the fuel. In order that the reader may understand what is meant by these terms they are explained briefly in the following paragraphs. The various determinations can be made only in the laboratory. As it is not practicable for the average home owner to make them, or have them made, his safest course is to purchase his fuel oil from a well-established and reliable source.

FLASH AND FIRE POINTS

The flash point of an oil fuel is the temperature at which the liquid, on being slowly heated under definite, specified conditions, begins to give off vapor in such quantities that when a torch is applied it will ignite momentarily, causing a flash. A flash point of 110° to 200° F. is considered to be within safe limits for fuels used in domestic furnaces. If heated further the vapor will be given off in larger quantities and the temperature at which it will ignite and continue burning (for a period of at least five seconds) is called the fire point. The fire point of an oil fuel should be low enough for the atomized oil to ignite fairly easily when a torch is applied.

Crank case oils, as they are taken from the crank cases of automobiles, trucks, and tractors, generally contain more or less gasoline and consequently may have low flash and fire points. The use of this oil as a fuel for oil burners, without refining, may thus be a dangerous practice.

VOLATILITY

One of the most important characteristics of an oil, for domestic oil-burner use, is its volatility. For burners of the vaporizing type the oil should be readily reduced to a vapor form without residue. Oil, unlike water, does not all vaporize at a definite temperature. The lighter fractions are vaporized at a lower temperature than are the heavier ones. It is important to know at what temperatures the light and heavy fractions are vaporized in order to determine the desirability of a given fuel.

VISCOSITY

The viscosity of an oil fuel is that property which resists any force tending to make it flow and is usually measured by the time required for a definite quantity of the oil to pass through an orifice of definite size under known conditions of temperature. For oils suitable for domestic burner usage, the viscosity should be low enough so that they will flow readily in cold weather.

WATER

Water is only slightly soluble in fuel oils, and when present it will be found mostly in the bottom of the container; however, in the heavy fuel oils some may be found in mechanical suspension.

SOLID MATTER

The solid matter content as ordinarily found in the light oil fuels that are suitable for domestic use is negligible. However, as a precautionary measure, it is advisable that all oils be strained before they are put into the consumer's storage tanks.

SULPHUR

The presence of sulphur in appreciable quantities in oil fuels is very undesirable. The sulphur dioxide, formed by the combustion of sulphur and oxygen during the process of combustion, has a very objectionable odor, and also injures the furnace by corroding the metal parts.

HEATING VALUE

The heating values of a pound of the different grades of oil fuels vary considerably and are not commensurate with the price of the oil. A light oil is usually thought to have a greater heating value than a heavy oil, and this is true on a pound basis. However, fuels are sold by the gallon and on this basis the heavier oils contain a larger number of heat units than the lighter oils. Table 2 shows the relative heating value of the various oil fuels, compared with the market prices of the products.

From this table it may be seen that a burner using the heavier fuel oils satisfactorily will be less expensive to operate, from the standpoint of fuel economy, than one which burns nothing but lighter fuels.

TABLE 2.—*Comparison of heat units and costs of oil fuels*

Products	Heat units per pound	Heat units per gallon	Cost per gallon [1]	B. t. u. per 1 cent cost
	B. t. u.[2]	*B. t. u.*	*Cents*	
Kerosene	20,000	136,000	13	10,460
No. 1 fuel oil	19,850	137,000	11	12,450
No. 3 fuel oil	19,500	141,000	9	15,660
No. 4 fuel oil	19,200	147,000	7	21,000

[1] These prices are only comparative and are subject to fluctuation.
[2] B. t. u. (British thermal units) is a measure of the heating value of the fuel.

PRODUCTION

As previously mentioned, there are three main classes of oil fuels on the market at the present time that are adaptable to domestic oil burners. These oils represent but a very small part of the total oil fuels produced. By far the larger quantity of this product consists of the heavier fuel oils which are not suitable for the present types of domestic oil burners.

The production of oil fuels during the last few years has been very large. The supply has exceeded the demand to the extent that its disposal has been a problem with the oil refiners. This condition, however, is rapidly changing. The development of commer-

cial and industrial burners now affords a yearly outlet for approximately 345,000,000 barrels of the heavier fuel oils, and with the development of the domestic oil burner still larger quantities of these oil fuels are being utilized. However, the future supply of oil fuels apparently will not depend so much on the above developments as it will on the extent to which oil fuels are to be used for making gasoline.

The products obtained from crude oils are not absolutely fixed but are subject to variation. The quantities of oil fuels that may be produced vary according to the processes of distillation, the kind of crude oil used, and the market conditions for the various products. The refiner of a crude oil of the Pennsylvania type that is rich in fine lubricants will obviously put as large a percentage as possible of his output into these higher-priced products and only that part of the crude which can not be made into the more profitable products will be turned into oil fuels. Likewise, the refiner of a Gulf coast crude which contains less of the finer lubricating oils will extract as much of them and of gasoline and kerosene as is practicable (taking into consideration market conditions) and dispose of the remainder as fuel oil.

In the case of the lighter crude oils the percentage of oil fuels available for domestic consumption is governed by the relative demand for gasoline, kerosene, and gas oil.

Gasoline is being extracted in considerable quantities from distillate oils through the process called "cracking." This consists of subjecting the distillates that have had the lighter fractions removed by the ordinary refining process to greater heat and pressure, thereby breaking up some of the remaining hydrocarbon combinations into gasoline, kerosene, and oil fuel. By this method some distillate fuel oil may be made to produce as much as 60 per cent of gasoline. Consequently, as the demand for gasoline increases, greater quantities of the distillate will be utilized for that product.

The demand for kerosene likewise affects the supply of oil available for domestic heating. The light domestic fuel is unrefined kerosene and can be made into kerosene by treating with sulphuric acid and caustic soda. In like manner the supply of gas oil available for domestic fuel will be governed by the demand for it in the manufacture and enriching of gas.

The amount of oil fuel usually extracted from the lighter crude oils, including those of 36° A. P. I. gravity or above, is about 20 per cent; however, with crude of lower gravity the percentage is greater. This amount is not always available for domestic fuels as some of it may be cracked into the lighter products.

It will thus be seen that no definite calculations can be made as to the amount of oil fuel that will be available for domestic heating. The percentage of oil fuels that may be extracted from the heavier crude oils will in some cases be as much as 70 per cent, but with the present types of domestic oil burners only a small part of this product can be used satisfactorily for house heating.

From the foregoing discussion it will be observed that no two localities will have identically the same product to offer nor will any refiner maintain the same gravity from one batch of his product to another. This accounts for the varying range of gravities.

FUTURE OF OIL FUELS

The availability of oil fuels for domestic burner usage is principally dependent on the future supply of crude oil and demand for its various products. The total production of crude oil in the United States in 1928 was approximately 900,000,000 barrels and the consumption was practically the same amount. The total gasoline content represented approximately 41 per cent of the crude run, of which nearly 33 per cent was obtained from oil fuels through the process of cracking. The demand for gasoline is growing each year, and if there is not a sufficient supply of crude oil to meet this demand, more and more of the oil fuels will be cracked into this product and correspondingly less will be available for heating and power purposes.

It is apparent that the future supply of oil fuels for heating and power purposes is more or less uncertain. However, it may be recalled that in years gone by, predictions were made by geologists and oil men at various times that the crude supply would soon be insufficient to supply the demands, and yet in due time other oil fields were discovered which were far beyond expectations. No one knows what new pools may be developed or what revolutionary methods of conservation or extraction may be brought about to alleviate the shortage if such should occur. Excess of demand over the supply of any product invariably increases the price of the product, and with increased price come increased profits which stimulate the production of the product. So, in the case of oil products, high prices stimulate drilling activities and thus tend to develop increased supplies. The results of conservatism and scientific research will also have an important bearing on the future supply.

EFFECT OF GRADE OF OIL ON ECONOMY

The grade of fuel that can be used is usually fixed by the design of the burner with respect to the method of atomization, the type of ignition, etc. The gravity-feed burners invariably are designed to burn only the high-grade distillates. The atomizing domestic burners at the present time use oil as heavy as No. 4. The Underwriters' Laboratories specify the oils which may safely be burned with each burner they have listed. The grade of oil which can be burned determines to a considerable extent the cost of heating by this method.

In tests conducted by the Department of Agriculture the relative economy of two of the most commonly used types of fuel was investigated. The burners with which these tests were conducted were rated by the Underwriters' Laboratories to burn safely either of the two fuels supplied to them in the tests. The properties of these fuels are shown in Table 3.

It will be observed from the table that the No. 3 fuel oil contained more heat units per gallon than the No. 1. These tests showed a slight saving in the quantity of fuel used in favor of the heavier oil. High-grade fuel may be 25 per cent higher in price than the low-grade product and in such case the saving in cost of fuel by burning the low-grade oil might be 25 per cent or slightly more.

TABLE 3.—*Properties of fuels tested*

	No. 1 fuel oil	No. 3 fuel oil
Degrees Baumé gravity	38.62	33.05
Flash point (closed cup) ° F	148	188
Flash point (open cup) ° F	160	202
Fire point (open cup) ° F	169	227
B. t. u.[1] per gallon	135,776	139,485

[1] British thermal units.

HANDLING AND STORING OIL AT THE HOME

In contemplating the installation of an oil burner provision for storing fuel should be considered. For coal, the average home owner generally provides storage capacity ample to contain all the coal used during the heating season. With oil this is not usually the case.

Aside from the added convenience of having a large supply of oil on hand, a more attractive price scale is offered to those consumers who buy oil in relatively large quantities. For example, in Washington at the time of writing, No. 1 oil sold for 11½ cents per gallon when purchased in 50-gallon lots, 10 cents when purchased in 275-gallon lots and 9½ cents when purchased in lots of 1,000 or more gallons. The No. 3 oil sold for 9½ cents per gallon in 50-gallon lots, 8½ cents in 275-gallon lots, and 8 cents in lots of 1,000 or more gallons.

The practice with some oil-burner companies is to state the price of the burner including a 50-gallon tank. Thus quoted, the price of the equipment is more attractive than if a larger tank were supplied but, in view of the above scale of oil prices, an installation of this kind will be seen to be uneconomical; and besides, the necessity of frequently refilling the tank is likely to become irksome. From the standpoint of convenience alone a large tank is desirable but there is an economic limit which is reached when the interest cost on the added investment offsets the annual saving resulting from lower oil prices made possible by the larger tank.

A point of importance to both the owner and the oil dealer is the placing of a fill pipe in such position that it may be conveniently reached from the tank wagon by means of a hose or pipe. Frequently a reasonably large storage tank is installed in such a position that it must be filled by carrying containers of oil a relatively long distance over lawns and walks. In doing this some of the oil is certain to be spilled on the walks and lawns and the resulting unsightliness and damage to vegetation, to say nothing of the odor, are objectionable. When the tanks are thus located the dealers offer great objection because of the increased cost of delivery. In the case of the 50-gallon storage tanks, the situation is almost always bad and delivery necessitates climbing stairs and transporting the oil for some distance. In fact, some oil dealers maintain that even with the increased prices as quoted above the servicing of 50-gallon tanks is unprofitable and intend to discontinue such service.

Large storage tanks are installed in various ways and usually must conform to the ordinances which regulate such matters in the particular locality.[4] From this tank the oil must be fed to the burner by suitable means, since regulations restrict the quantity of oil which may be stored above the burner level. A simple means of transferring oil from the main to an auxiliary tank is shown in Figure 2. In many types this transfer of the fuel from the storage tank to the burner is made automatically by means of a pump or by suction produced at the burner itself. A typical full-automatic installation is shown in Figure 3.

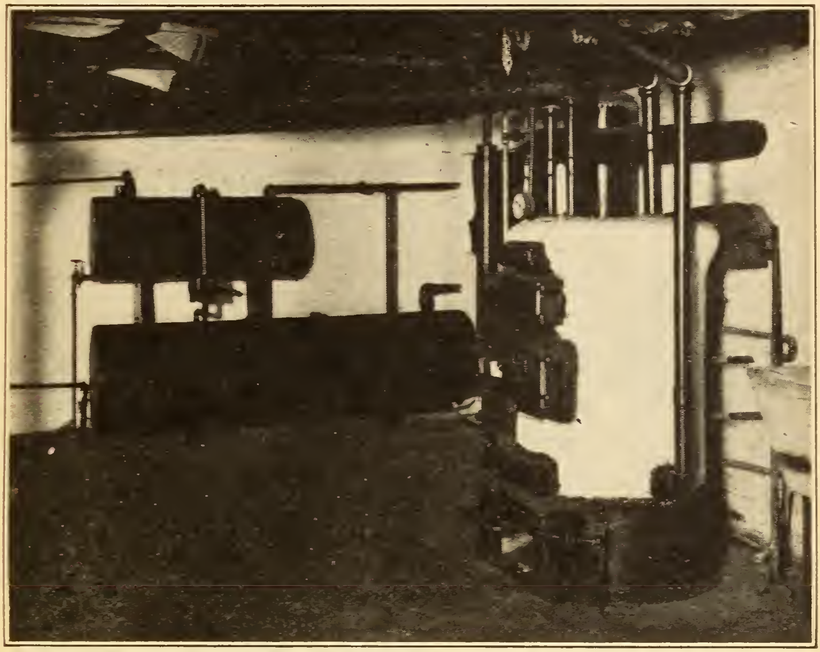

FIGURE 2.—Vaporizing burner with automatic control. The ignition is by a continuous gas flame, which also serves as a source of heat for the vaporizing plate. Note the storage and auxiliary tanks and the hand pump used for transferring the oil from the former to the latter

OIL BURNERS

The primary function of an oil burner is to break up the oil into fine particles and so mix it with air that proper combustion will result under suitable conditions of temperature. A number of equally effective schemes are employed, one of which is shown in Figure 4. Combustion, or burning, is any kind of chemical combination in which heat is liberated. In domestic heating combustion is caused by the combining of the elements of the fuel with the oxygen of the air. When this combustion is completely carried out the maximum heating value of the fuel is realized.

[4] The Underwriters' Laboratories, Chicago, Ill., issues pamphlets of directions for this work.

CLASSIFICATION

There are on the market a number of burners for use in house heaters, varying in the method employed to prepare the fuel for combustion. In general they operate upon one or the other of two broad principles—namely, the vaporization or the atomization of the oil prior to burning. Burners may be classed, then, as either vaporizing, comprising the so-called gravity-feed type, or atomizing, including those in which the oil is broken up by mechanical or spray devices.

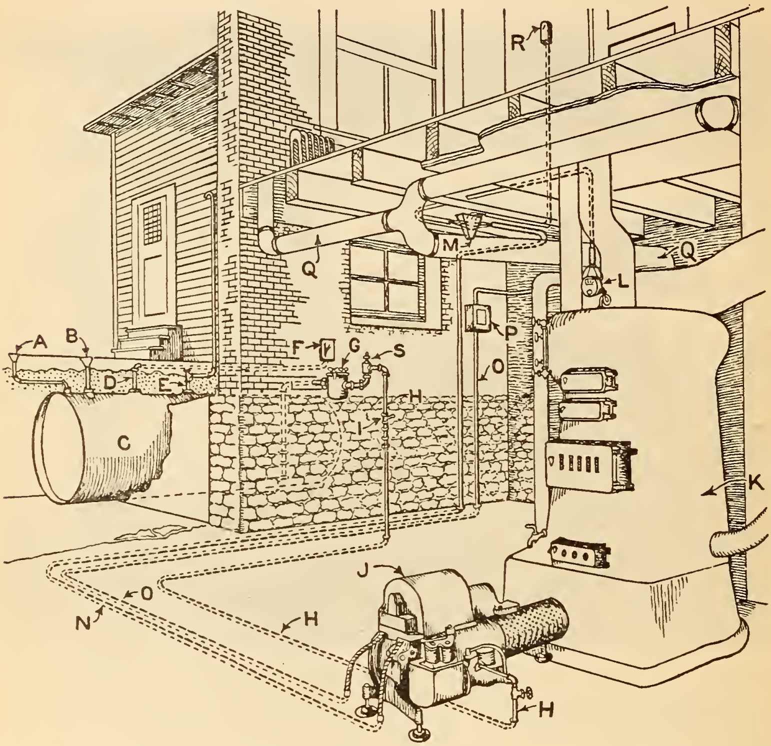

FIGURE 3.—Complete automatic oil-burner installation. *a.* Filling box; *b.* Clean-out and measuring box; *c.* Underground storage tank; *d.* Tank-gauge tubing; *e.* Air vent; *f.* Tank gauge; *g.* Strainer; *h.* Oil feed pipe to burner; *i.* Globe or self-closing valve; *j.* Oil burner: *k.* Heating plant; *l.* Safety-control switch; *m.* Junction block; *n.* Thermostat wire to burner; *o.* Service wire to burner; *p.* Cut-out switch; *q.* Pipes to radiators; *r.* Room thermostat; *s.* Antisyphon valve

GRAVITY-FEED VAPORIZING TYPE

This is the simplest type of burner, very often consisting merely of one or two rough castings which are set inside the furnace (fig. 5) and its initial cost is low. Some device, such as a "hot plate," is essential for volatilizing the oil so that a vapor will be produced, as illustrated in Figures 6, 7, 8, and 9. The air to support combustion is generally brought into the furnace by the natural draft produced by the chimney. Some rather ingenious means are used to induce an intimate mingling of this air with the vaporized fuel, but in general good combustion is not obtained by this method unless a

highly volatile fuel is used. Although the principle seems simple enough, the fuel and air are not mixed with sufficient thoroughness to give a good clean flame. In the cheapest burners of this class the control is entirely manual; the burner is started by hand, and the control of temperature is effected in like manner. In some cases automatic control has been applied with apparent success. The gravity-feed vaporizing burner is limited to the use of the relatively high-priced fuels.

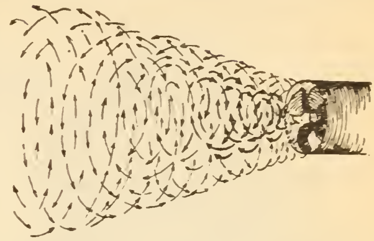

FIGURE 4.—A method of commingling air and atomized oil by whirling each in contrary direction in conical streams. The oil stream comprises the inner cone, while the air stream comprises the outer

ATOMIZING TYPE

The atomizing type of oil burners may be subdivided into those which break up the oil by purely mechanical means and those which atomize the oil by spray devices.

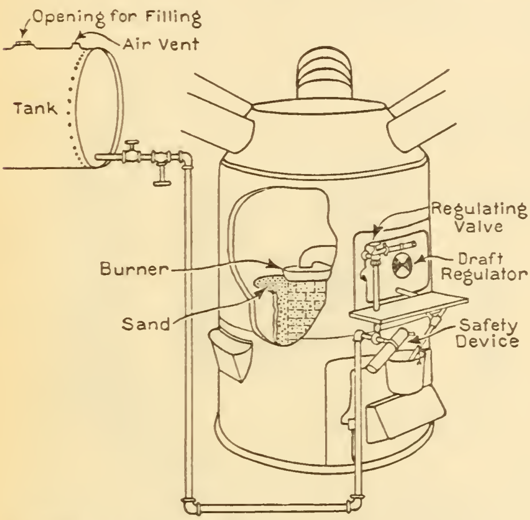

FIGURE 5.—A simple manually controlled vaporizing burner installation in a warm-air furnace

In one mechanical-type atomizing burner the oil is put under pressure and forced through a small opening to break it up into minute particles, and it enters the furnace as a vapor spray. Air is supplied by a blower or pump and so regulated as to bring about the proper combustion of the fuel (fig. 10).

In another type of mechanical atomizing burner the oil is broken up by being thrown from the periphery of a revolving disk or cup. The disk or cup speed is relatively high and is sometimes obtained by positive gear drive or by friction drive from an electric motor. Figure 11 illustrates a motor-driven centrifugal atomizing burner.

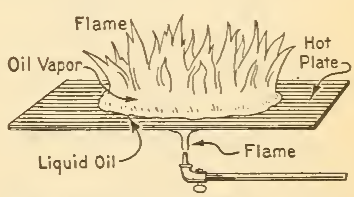

FIGURE 6.—Illustration of burning oil by vaporizing method

The spray type of atomizing burner consists of air and oil nozzles so arranged that air supplied by a motor-driven compressor blows directly over the oil nozzle and creates a partial vacuum, as illustrated in Figures 12 and 13. The oil is drawn up from the supply reservoir by the vacuum thus formed

and is atomized or broken into minute particles by the air pressure, in preparation for ignition. The rate of feed is governed by the air pressure and the size of the nozzle openings. This principle is not unlike that of the ordinary carburetor employed in the gasoline engine.

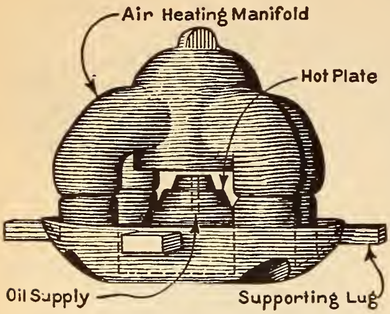

FIGURE 7.—Casting which constitutes a simple gravity-feed vaporizing type burner

The atomizing type is generally controlled automatically by a room thermostat which so regulates the burner as to maintain the desired room temperature. Figures 2, 14, 15, 16, and 17 illustrate different types of oil-burner installations. Figure 18 is a sketch of one type of atomizing burner, the mechanism of which is practically entirely within the furnace. The mixing chamber is practically the only element of the burner proper which is exterior to the furnace.

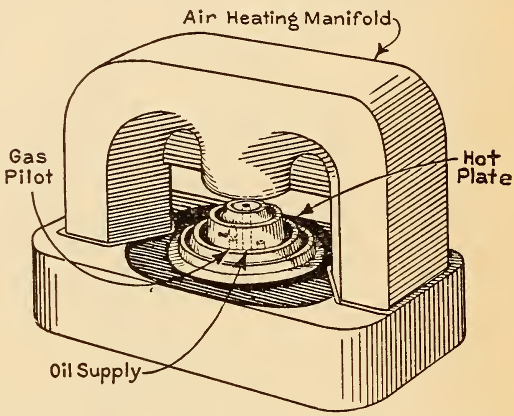

FIGURE 8.—Casting of a vaporizing burner with which is incorporated the continuous-burning gas pilot and plate-heating flame

COMBUSTION

Oil fuel used by domestic oil burners contains principally hydrogen and carbon, with much smaller quantities of oxygen, nitrogen, and sulphur. Of these elements, the carbon, hydrogen, and sulphur are the ones that burn or combine with oxygen. The oil fuels that are now employed for domestic heating are very uniform in composition and contain roughly 84 per cent carbon and 13 per cent hydrogen; the oxygen, nitrogen, and sulphur taken together compose the other 3 per cent. A pound of fuel of this composition will require about 14¼ pounds of air for perfect and complete combustion.

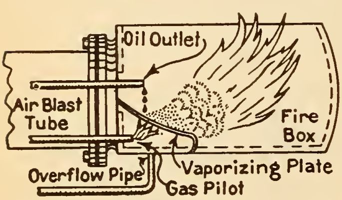

FIGURE 9.—Vaporizing type of burner in which the gas pilot also heats the vaporizing or hot plate. Air is supplied positively by a motor-driven blower

Insufficient air supply is one cause of clouds of dense smoke and soot. Sometimes the draft prevailing under this condition is not sufficient to carry off the sooty, smoky products of combustion, and they permeate the entire house, with damage to draperies, hangings, and household goods. This form of combustion is inefficient in that the fuel is not

entirely consumed. It is not easy to supply precisely the amount of air theoretically required for perfect combustion and even if this were accomplished the intermingling of the air and oil probably would not be sufficiently complete to give perfect combustion. An excess of air is essential to insure that each subdivided bit of oil is provided with the amount of air necessary. In practice, possibly 25 to 30 per cent more air is supplied than that which is theoretically required. An excess of air is also advantageous with automatic operation where the burner is started and stopped frequently, in that it lessens the smoky condition which almost invariably occurs when the burner "comes on."

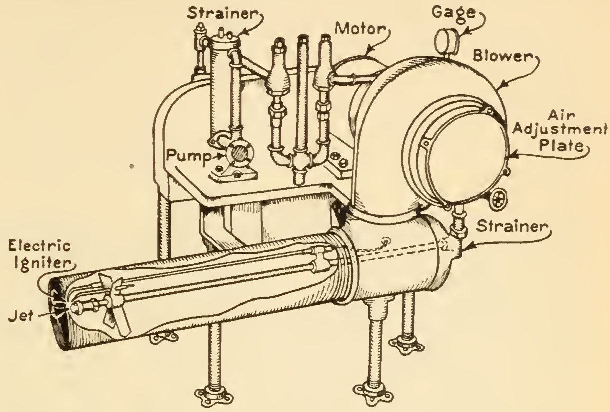

FIGURE 10.—Motor-driven atomizing burner of the electric-ignition type

IGNITION

Burners may be subclassified according to the manner in which the fuel is ignited. With the manually-controlled gravity burner, the hot plate is preheated by a wick which is saturated with oil and ignited by a torch. The plate must be heated to a temperature sufficient to vaporize the oil falling upon it. The heat of combustion is supposed to do this once the flame is started. The temperature of the house is maintained at a desired point by increasing or decreasing the intensity of the flame by means of a valve in the oil line, or the burner may be operated at a fixed intensity and then completely shut off as the condition may demand. Whenever the burner is off for a few minutes the hot plate must be preheated again before the oil can again be vaporized and ignited.

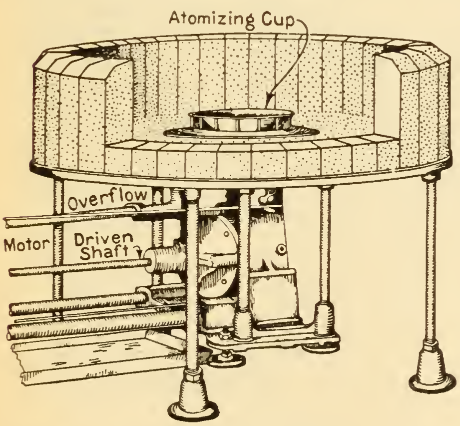

FIGURE 11.—Motor-driven centrifugal atomizing burner

In some automatically controlled vaporizing burners a gas flame is used for heating the hot plate and as a pilot light for igniting the fuel. This is shown in Figures 8 and 9. The gas flame burns continuously and keeps the hot plate at such a temperature as to cause the oil to vaporize when it is admitted to the apex of the plate and trickles down over the corrugations shown. At the same time the pilot flame licks through holes drilled in the hot plate and ignites the mixture of vaporized oil and air. The automatic device in this case merely shuts off or opens a valve in the oil line to the burner.

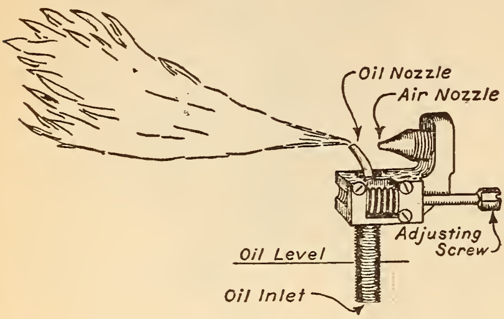

FIGURE 12.—Atomizing of oil by air jet or spray

With the atomizing type of burner it is necessary to introduce a flame or electric arc within a region which is filled with an intimate mixture of oil and air in such proportions as to make it comparatively easy to ignite. Ignition methods used may be roughly classified as gas, electric, electric gas, or electric oil. With a gas pilot, ordinary illuminating gas is used to provide a continuous source of heat and is so placed as most effectively to bring the mixture of oil and air to such a temperature as to cause combustion. The pilot flame is sometimes caused to expand at the time the burner "comes on" and by this means the danger of extinguishing the pilot light is somewhat lessened and ignition is presumably hastened.

In the case of electric ignition, a spark is introduced into the region of the charge. Electric-spark machines are either continuous or intermittent. In the continuous-spark type the spark continues during the entire time the burner is in operation. In the intermittent type the spark is active only during the time necessary to ignite the charge, and then ceases. Various advantages are claimed for each type by the designers.

In the electric-gas type a gas pilot is turned on, the gas being ignited by a spark. The pilot light then ignites the charge. Still another device is the electric-oil ignition in which an independent atomized mixture is ignited by an electric arc and is utilized as a source of heat energy to ignite the charge of the burner proper.

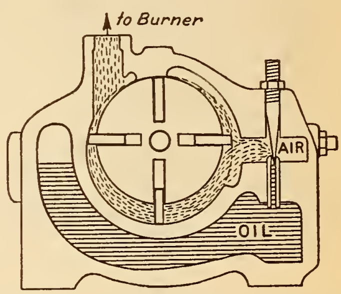

FIGURE 13.—Application of rotary pump and needle valve to atomize oil and mix it with air

Many favorable characteristics are advanced by advocates of these various schemes, but it must be borne in mind that the type of burner selected must conform to the particular igniting facilities present, whether gas or electricity, or both.

AUTOMATIC DEVICES FOR CONTROL OF OIL BURNERS

The oil flame is extremely rapid in heating and if not controlled in some manner will build up temperatures and pressures in the heating system which may prove dangerous. If the drafts of a coal furnace are inadvertently left open the worst than can happen is to burn up the coal in the furnace. It is true that temporary overheating or increase in pressures might occur, but in all probability no serious effects would be produced. With the oil burner, however, overheating would go on as long as the oil supply lasted.

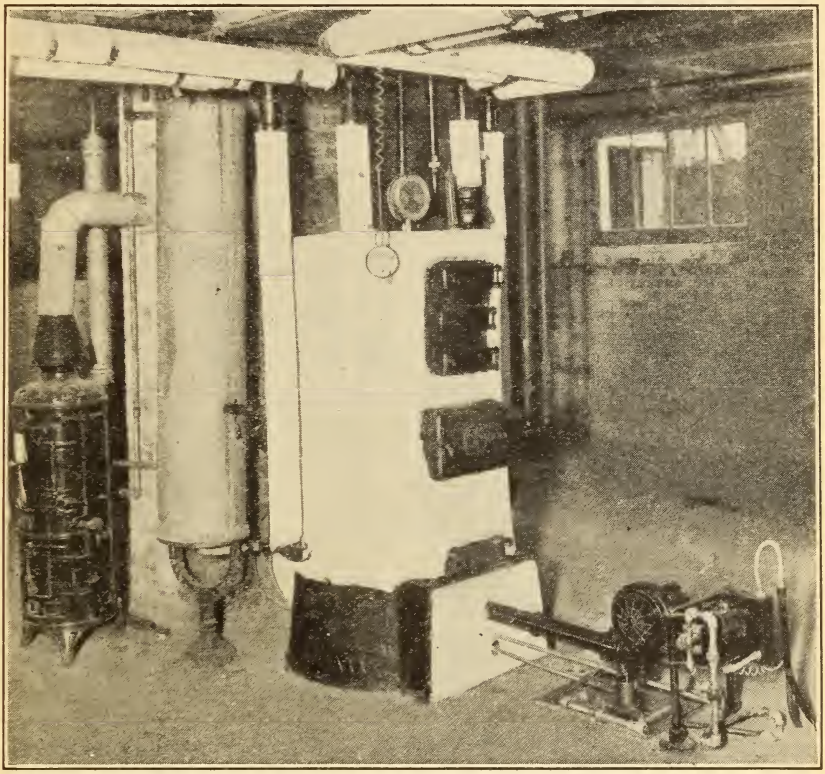

FIGURE 14.—Installation of burner in small hot-water boiler. This burner is of the atomizing type, and air is supplied positively by means of a motor-driven blower. Ignition of the fuel is made by a gas pilot. Full automatic control

The simple gravity-feed vaporizing type is generally manually controlled, and in order to maintain the desired room temperature the fuel admission is regulated by hand—at best an irksome job. When the house is deserted the fire is either extinguished or cut down so as to maintain a minimum temperature sufficient, at least, to prevent freeze-ups. Very frequently burners of this type operate unsatisfactorily when throttled so that it is safer to entirely cut off the flame. This, of course, introduces the danger of freeze-ups and accompanying damage. In some instances automatic control has been applied to the gravity-feed type of burner, and either the oil flame

is increased and decreased as required, or the burner is rendered entirely inactive when the room temperature rises above a desired point. The power-atomizing type of burner best lends itself to a variety of automatic controls, and it is in this type that such controls have been most successfully utilized.

THE ROOM THERMOSTAT

The thermostat is the device on automatic burners which renders the burner active or inactive in the process of maintaining desired room temperatures. In the thermostat there is a member, actuated by temperature changes, which operates to maintain a constant temperature by shutting off or starting the burner. The thermostat is placed in a room, generally the living room, in which it is desired

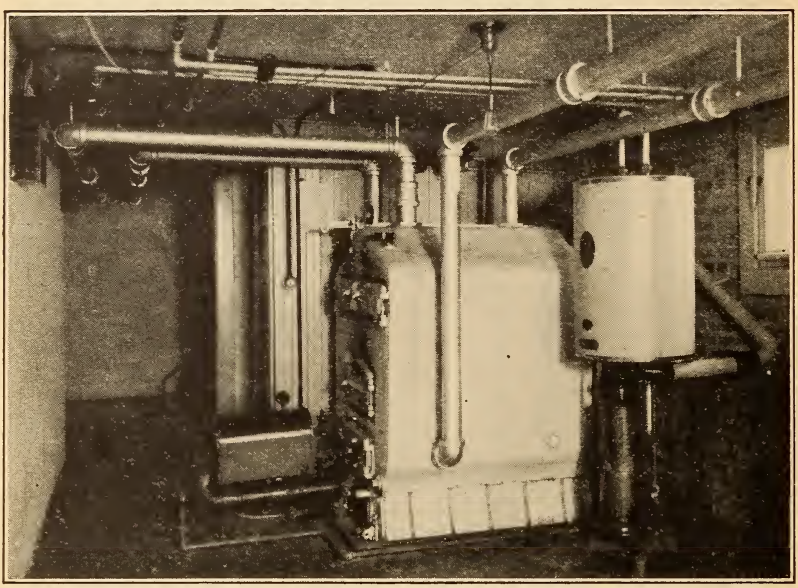

FIGURE 15.—Installation of burner in a sectional boiler. This burner is of the atomizing type, and air is supplied positively by means of a motor-driven blower. Ignition is by electricity and gas. Full automatic control

to maintain the temperature constant and then so adjusted as to give the desired temperature by moving a small pointer which passes over a scale graduated in degrees Fahrenheit.

It is obvious that if the thermostat is improperly placed the room temperature can not properly be controlled by it. The height should be approximately at the breathing level—about 5 feet from the floor. It should be placed on an inside wall and in such a position as to be protected from abnormal drafts of air as, for example, from stairways and entrances. It should not be placed too near chimneys, radiators, warm-air registers, hot-water or steam pipes and other such direct sources of heat. Particular care must be taken to avoid placing of the thermostat near concealed steam or hot-water pipes. Many instances of unsatisfactory operation have been traced to improper placing of the thermostat.

DUAL CONTROL

In automatic oil-burner installations there are boiler controls in addition to the room thermostat. The boiler controls are termed hydrostats, if it is a hot-water system, and pressurestats if it is a steam system. (Steam in this case is used in the general sense to include vapor, vacuum, and low-pressure steam plants.) This boiler control is operated dually with the room thermostat and controls

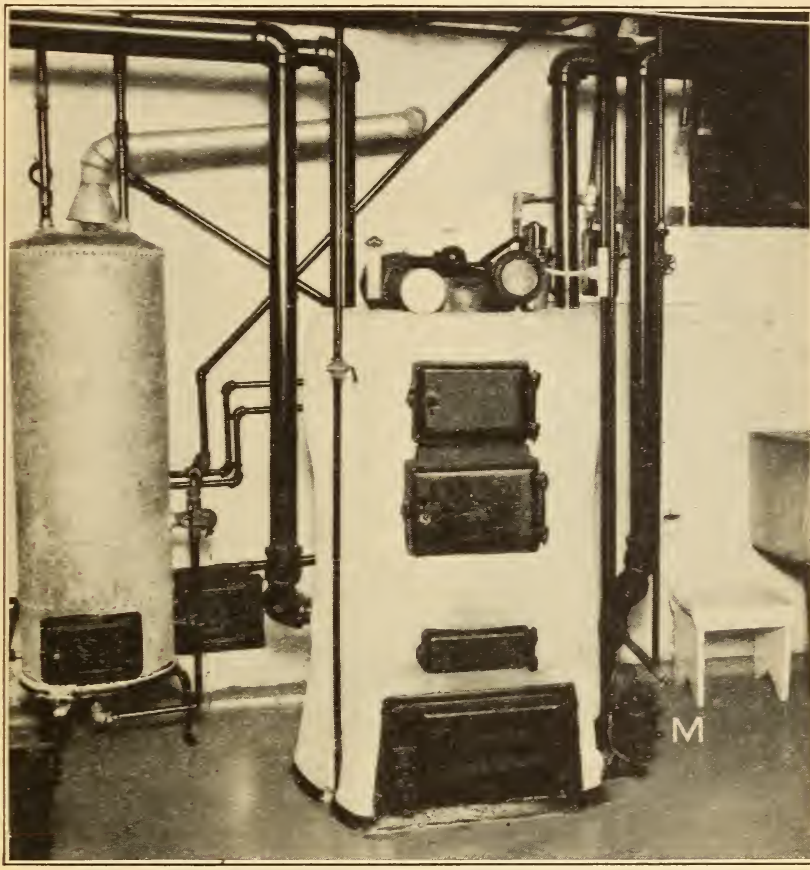

FIGURE 16.—Burner installed wholly inside of the boiler. This burner is of the atomizing type, full automatic control, and has a vertical motor inside of the furnace which inducts the air and fuel in positive quantities through the mixing chamber M. Some additional air is drawn in around the motor by natural draft and serves to prevent the motor from overheating

conditions at the boiler while the thermostat controls temperatures in the room. By the use of the hydrostat the temperature of the water in the boiler is kept within certain limits, and in the case of the pressurestat the steam pressure is kept within certain limits regardless of the temperature conditions in the rooms.

These boiler controls make for safety by limiting the boiler pressures and temperatures prevailing regardless of the call of the room thermostat for heat.

EMERGENCY OR SAFETY CONTROLS

In addition to the controls described above which regulate heat, it is essential that precaution be taken to cut off the burner in the event that ignition fails to take place. In such burners as permit, a drip bucket or sump is provided to catch the unburned fuel which flows to it when ignition fails. This device trips when a certain quantity has been delivered to it and either cuts off the oil supply or breaks the power circuit, in either case rendering the burner in-

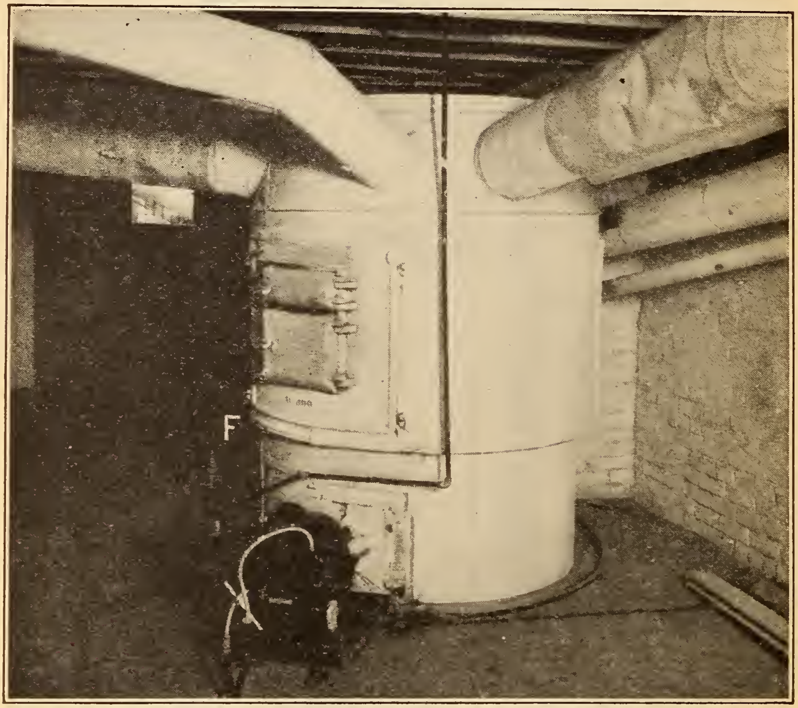

FIGURE 17.—Application of oil burner to warm-air heating plant. The job shown above was quite satisfactory. Prior to installing the burner the furnace was overhauled to repair the inner casing so as to prevent the passage of the products of combustion from the fire pot into the warm-air duct and thence into the rooms. The practice followed by the installer of the burner pictured here is to provide a circulating fan, F, placed in the cold-air return duct in order to facilitate the movement of the air through the furnace into the rooms and back to the furnace. By observing this practice undoubtedly greater success in the application of an oil burner to warm-air plants could be had

operative as to the generation of heat and flow of oil. The machine must then be reset by hand before operation can be resumed. One of the chief objections to this control is the clogging of the line which delivers the unburned oil to the drip bucket or sump, owing to the accumulation of soot, scale, etc. Liberal passages offset this tendency to a great extent.

Another emergency control is designed on the assumption that so long as the pilot light burns the charge will be ignited and accordingly a thermostatic member which is exposed to the heat of the pilot light breaks the power circuit when the pilot light is extinguished.

When the general design of the burner is such as to make the catching of unburned oil and its subsequent delivery to a sump or drip bucket impracticable. the " stack control " is utilized. A thermostatic member is placed in the stack and if, after a predetermined period, it does not become heated—indicating that the burner has failed to function—the thermostatic member breaks the power circuit and stops the motor and supply of oil.

Low-water emergency controls are also applied in some installations and there are other devices, such as alarm bells, which are employed in conjunction with these emergency controls. Doubtless even more ingenuity will be manifested in this direction as design progresses.

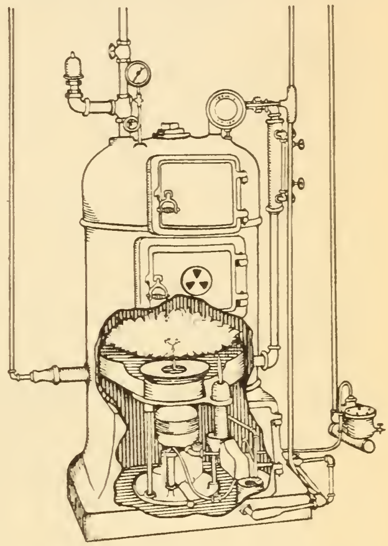

Figure 18.—Atomizing burner of the type which is practically entirely inside the furnace. Note the vertical motor which by means of a suction pump draws oil and air from a mixing chamber and discharges it into the combustion chamber through a hollow armature shaft

SELECTING AN OIL BURNER

In selecting a burner it is well to obtain in advance all the information possible, keeping in mind experiences of other purchasers, and not to seek the " best " burner but rather one that is handled by a reliable organization which employs capable men to " service " their product. It is safe to conclude that such an organization will handle at least a reasonably good product.

One reads of companies who maintain that they have a burner which cures all heating ailments. They ship the burner together with printed instructions for installation. If such a device operates at all satisfactorily upon installation it is due to good fortune only. Previously to the selection of a burner, a study of the individual heating problem involved always should be made if the best results are to be attained. If the plant has heated the home satisfactory with coal, the problem is simplified somewhat but not entirely solved.

ITEMS TO BE CONSIDERED

The following items especially should be considered in selecting an oil burner:

1. Reliability of local representative, stability of business. A first-grade burner improperly installed, or without oportunity of procuring service, will be unsatisfactory.

2. Grade of fuel which burner is capable of burning. Tests show that the burners which burn the relatively low grades of oils attain the greatest economy. The type of fuel available in the community is to be kept in mind in selecting a burner.

3. Amount of noise. A burner which is noisy is highly objectionable. The purchaser may insist on a noise clause in his contract so that in the event that the noise proves unbearable after a reasonable

trial, the contractor shall remove the burner and relieve the purchaser of all obligations.

4. Amount of cleaning or attention required.

5. Accessibility. Some buyers insist upon a burner which may readily be removed and allow the replacement of grates in order to return to coal burning in the event that the oil burner should fail or if current becomes unavailable for some time. Some owners, especially in isolated places, suffer loss of electric power for days at a time during severe storms; or the roads may be impassable so that the service man may not be available for a considerable time. Such an owner should insist upon a burner which can be pulled out by inexperienced help in order that he may return temporarily to the use of coal.

6. Availability of gas or electricity. Some of the simpler burners of the vaporizing type require no auxiliary power, whereas some require gas. The atomizing type generally requires gas or electricity—sometimes both.

7. Capacity. It is, of course, essential that the oil burner selected shall be of such capacity as to provide for the maximum heating demand. The practice of manufacturers in supplying different heating capacities varies considerably. Some manufacture a series of burners which are of similar construction but of various sizes and oil-burning capacities. Others make two or three types of burners, each of which can be so adjusted as to fit a range of heating demands. Still others make but one burner and depend upon adjustments to accommodate the various heating requirements. The quantity of oil which must be burned can be determined approximately from the amount of radiation installed, or in the case of a warm-air installation the equivalent heat-unit requirements may be used as a basis. It is sufficient to assume a maximum requirement of about one-fifth gallon of oil per hour for each 100 square feet of direct hot-water radiation, and about one-third gallon of oil per hour for each 100 square feet of direct steam radiation. These figures are approximate peak demands to be used only for determining the size of burner mechanism which should be supplied. It is not to be expected that the burner will operate at this rate during the entire season, therefore these figures can not be used for computing the seasonal fuel consumption.

8. Price. The simple gravity-feed vaporizing type requires only meager equipment and has an apparent attraction because of the low initial cost, which for some types is less than $50. However, as indicated elsewhere in this bulletin, the gravity-feed burners require the higher-priced distillates and burn these with relatively low efficiency. Also, from the standpoint of convenience, the vaporizing types are not as satisfactory, in general, as the atomizing type.

Some vaporizing types of burners have the outward appearance of an atomizing type—that is, motor, full automatic control, etc. These types run up in cost, in some instances equaling the cost of the atomizing burners. Their combustion is considerably more efficient than that of the simplest type, but the fuel recommended for them is the higher-priced distillate.

With the atomizing type the equipment is more elaborate, and the cost therefore runs higher than for the vaporizing types. Atomizing

burners, installed, range in cost from about $400 to $1,000, including a fair-sized oil-storage tank.

ADJUSTMENT OF BURNER

After a burner has been installed in a boiler, it must be properly adjusted for efficient service. Assuming that the burner has been properly set and such details as impingement of burning gases directly against water-cooled surfaces have been guarded against, the next step is to establish the fuel and air rates.

With the gravity type of burner, using natural-draft air supply and manual fuel control, the adjustments are simple but as a rule not very satisfactory. Adjustment is made by hand as the heating demand changes. When the room temperature is high enough, the burner is cut down or entirely stopped, depending on the weather conditions. When the room temperature is too low the opposite procedure is followed. These adjustments are made by altering the fuel valve setting. The air admitted to the burner is controlled by the stack damper, also manually operated. Thus with this type of burner no fixed setting of the fuel valve or air damper can be made; these settings are continually being altered as the heating demand is changed. The combustion is likely to be poor because the regulation of air and fuel is dependent upon the skill of the inexperienced owner. Often, with this type of burner, the air supplied is much in excess of that actually required and inefficient operation is the result.

With the atomizing or power type of burner, adjustment can be made to a much finer degree. The control of the room temperature is provided automatically by the room thermostat which renders the burner inoperative or operative as the temperature rises above or falls below the desired level, but no alteration of the fuel or air adjustments is made other than complete turning on or off. Thus a burner of this type can be permanently set and uniform operation is attained.

The adjustment of the burner consists of regulating the quantities of oil and air admitted. The rate of oil consumption depends of course on the heating load, that is, size and character of house, temperature to be maintained, etc. The adjustment of the air admission depends upon the quantity of fuel to be burned. A definite quantity of fuel burned requires a definite quantity of air.

The regulation of the air supply can best be made with the aid of an apparatus for analyzing the products of combustion, although the appearance of the flame is also an indication of the mixture of air and fuel. It is well for the average owner to refrain from any attempt to adjust the burner.

With any oil burner, it is important to give considerable attention to the setting of the dampers, especially the stack damper. The underwriters have the following to say regarding this:

> Dampers which may entirely close the chimney uptake are prohibited. Damper area should be carefully determined in each case but in no case shall it be greater than 80 per cent of the internal cross-sectional area of the uptake.

Very often, in the adjuster's zeal to cut down the loss of heat up the stack, he will almost entirely close the stack damper, resulting in a leaking of burned gases into the rooms of the house. This

should be guarded against. Very frequently odor from an oil burner can be traced to this leakage of gases into the rooms of the house when the damper has been closed. One simple method of determining whether or not this leakage is occurring is to place a candle flame, or flame of a match, near the fire door which has been slightly opened, as illustrated in Figure 19. The flame should be drawn into the furnace; if it is not, there is indication of a pressure in the furnace caused by a blocked chimney passage.

The automatic controls very often require some little adjustment after installation in order that the proper room temperature may be maintained. Adjustments of oil burners had best be left to the installation men and generally there should be no tinkering on the part of the owner.

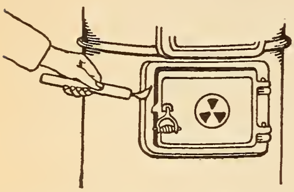

FIGURE 19.—Test for leakage of gases of combustion to room

THE HEATING PLANT

The circulatory systems employed for heating may be classified as follows: (1) Hot water, (2) steam, (3) vapor, (4) vapor-vacuum, (5) vacuum, (6) warm air.

These various systems lend themselves in different degrees to satisfactory oil burning. The hot-water system is perhaps the most desirable oil-burner type because a large amount of heat energy is stored up in the water system which allows the burner to be inoperative for longer periods than is possible with other heating systems.

Warm-air furnaces represent a large percentage of the heating plants of this country and the question of the adaptability of oil burners to this type of heater is of great interest. Perhaps the principal difficulty to be overcome is the same that often exists in a warm-air plant when coal is used, that is, the leakage of the products of combustion from the fire pot into the warm-air space of the furnace and thence to the warm-air ducts and into the rooms of the house. This condition is possibly somewhat more acute in the case of an oil burner than with the ordinary coal-fired furnace because of the intermittent nature of the flame. As a rule, the burner is either operating at its maximum capacity or is entirely inoperative, as controlled by the room thermostat. The alternate heating and cooling has a tendency to loosen the seams and permit the passage of gases from the fire pot into the warm-air passages.

To overcome this difficulty some oil-burner dealers insist upon a removal of the outer casing of the furnace and a thorough inspection of the inner fire-pot sections for the purpose of locating leakage. Any leaks are closed in suitable manner and the outer shell restored. Some of the higher grade furnaces with welded joints are particularly effective in resisting the effects of the high temperatures of the oil-burner flame. Because of the generally better design and construction of the present day warm-air installation, and the increased quietness of the oil burner, the application of oil burners to such a heating system is now quite satisfactory.

COMBUSTION-SPACE REQUIREMENTS

To obtain satisfactory combustion it must be carried out in a region of high temperature. Looking into an operating furnace one

probably will conclude immediately that that condition is always fulfilled, but this is not the case. When the mixture of oil and air is ignited, the temperature rises rapidly and the products of combustion quickly expand and fill the whole combustion space. It is this rapid increase in volume which contributes so largely to the noise of the oil burner. The inner surface of the combustion pot, by virtue of its high rate of heat transmission, offers a considerable cooling surface to the burning mass which comes in contact with it and it is largely this cooling which arrests the combustion at a premature stage and causes sooty deposits. The proper use of fire brick and refractory cements tends to prevent the contact of the hot and incompletely burned gases with the cold walls of the furnace and avoids soot formation and loss of heat value of the fuel. The fire brick or refractory cement are relatively poor conductors of heat and therefore become very hot. When the unburned gases come in contact with them combustion is not arrested. See Figure 11 for one method of bricking up. This is one of the problems of installation that must be solved by the oil-burner manufacturer before he can reasonably give assurance of satisfactory operation to the prospective buyer. Soot formation is to be avoided, as a deposit in the furnace or stack leads to inefficiency and is a dangerous fire risk. Figure 20 shows a deposit of soot in heating passages of a water boiler.

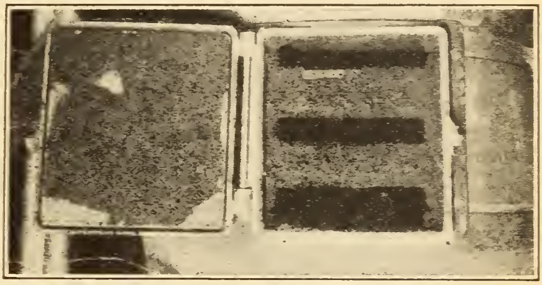

FIGURE 20.—Soot deposited in heating passages of boiler

EFFICIENCY

The term efficiency is likely to be misleading when applied to oil burning for domestic heating. The term "burner efficiency," for example, although very commonly used is very nearly meaningless. The carbon dioxide content of the gases that pass up the stack is the criterion by which the combination must be judged.

With the fuels ordinarily used in domestic burners the maximum amount of carbon dioxide passing up the stack is about 15 per cent. More air than that theoretically required is generally supplied and the carbon dioxide content may fall as low as 10 or 12 per cent. This may be done to avoid soot deposits and without greatly impairing the combustion. A 30 to 50 per cent excess of air is desirable in order to permit a safe margin against the production of a smoky, sooty condition inside the boiler. An oil burner which, with a reasonable excess of air, is not capable of burning oil fuels without smoke can not be satisfactory.

"Over-all efficiency" is a term applied to a complete installation, including the heater itself, which indicates the percentage of the heating value of the oil that is utilized for warming the house. The over-all efficiency is the ratio between the heat energy of the fuel

which is used in heating the water or air (not air passing up the stack), as the case may be, to the total amount of heat contained in the fuel. For example, suppose that for each gallon of an oil containing 140,000 heat units 70,000 heat units are actually made available for heating the house; then the over-all efficiency would be 70,000 divided by 140,000, or 50 per cent. No other "efficiency" is significant. It is true that a high so-called burner efficiency is imperative, but this does not insure high over-all efficiency.

BOILER DESIGN AS AFFECTING OVER-ALL EFFICIENCY

Satisfactory results from the burning of oil as well as other fuels are dependent on several factors. In the first place the plant must be designed and laid out according to the accepted principles of heating. This means (referring to hot-water, steam, or vapor) that the radiation must be properly proportioned, that the lines must be of proper size and free from pocketing, and that suitable means for the removal of condensation and venting of air must be provided. Furthermore, the size of boiler must correspond to the load imposed on it. Boilers are rated by the manufacturers on a basis of the amount of radiation which can be supplied by them and this limitation should be observed strictly. If a boiler of inadequate capacity is installed, the result will be overloading and a loss in over-all efficiency. This is particularly true in the case of oil burning where the losses up the stack may be very great.

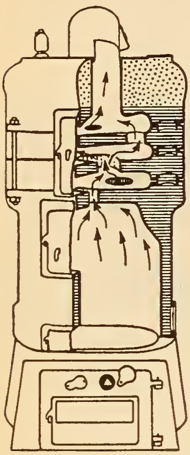

FIGURE 21.—Sectional view of round heating boiler, illustrating addition of sections to increase heating capacity

The form of the boiler is also important. Assuming that the boiler is of proper size so far as rating is concerned, it should be understood that some shapes and designs of boilers are more suitable to certain types of oil burners than to others. By proper alteration through the use of refractory brick or cement, certain boilers can be made more suitable for burning oil.

One of the most important factors affecting the efficiency of a boiler with properly installed burner is undoubtedly the size as regards the "gas travel" or square feet of heating surface. Figure 21 illustrates how sections may be added to obtain additional heating surface with some built-up boilers. Almost always the addition of sections will effect such economy as to pay for the added cost of providing the sections. Few boilers which at present are used for coal burning are suitable for burning oil to best advantage. Either the combustion volume or the flue gas travel, or possibly both, are insufficient to obtain the best results.

It is well to bear in mind that the boiler is the element which is most important in the determination of the over-all efficiency of the system. An oil burner installation is no more efficient than the boiler in which it is installed. The Department of Agriculture obtained practically the same degree of perfection in combustion in

nearly all of the atomizing types of burners tested, but the oil burner is merely a device for preparing the oil for burning and the absorption of the heat thus generated depends to a large extent upon the boiler.

The designers of some burners have resorted to different schemes to increase the flame travel before impingement on the water-cooled surfaces of the boiler. Figures 22 and 23 present two different schemes for accomplishing this.

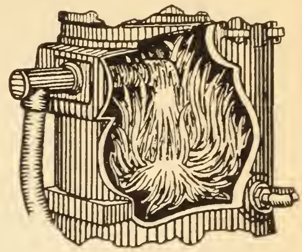

FIGURE 22.—Type of burner in which the burning mixture is projected downward against a refractory bed and then up along the direct heating surface. The objective is to gain a long flame travel before impingement on cold surface is suffered

COST OF HEATING WITH COAL AND OIL

In comparing the cost of heating with oil and coal, all the conditions and factors must be considered. The personal element enters to a much greater extent with the coal fire than with the oil fire and therefore there is greater opportunity for poor firing. It is safe to say that only a small percentage of householders operate their furnaces to best advantage. With the coal fire there is the condition of overheating during the milder periods of the heating season, especially when no automatic room temperature control is used. The temperature regulation is frequently achieved by opening windows and doors rather than by control of the fire. These things greatly lower the seasonal plant efficiency of the coal burner. Moreover, in homes where coal is burned, some auxiliary heating devices such as portable oil, gas, or electric heaters may be put into service in the mild early and late heating periods. The cost of operating these should be charged against the coal-burning plant.

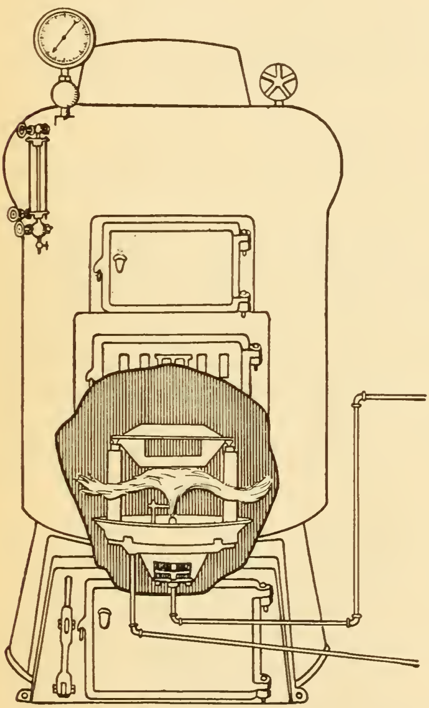

FIGURE 23.—Type in which the burning gases are directed vertically upward against a refractory target

With the oil burner the personal element is largely removed, assuming that the burner has been properly installed and regulated. There are characteristics of the oil burner which tend to increase the cost of oil burning, but they are additional costs for additional comfort. An oil burner may be operated earlier and later in the heating season because of the ease of starting up, and the fact that presumably a minimum of care is required afterwards. The room tempera-

ture, with a good automatic oil-burning installation, is maintained practically constant at any ordinary desired temperature, which may or may not be the case with the coal burner.

It should be borne in mind that the average oil-burning installation is merely a change-over from coal burning to oil without any radical change in the boiler. There are many types of boilers in use, and some are far more suitable for oil burning than others. A comparison between the costs of buring oil and burning coal should therefore be confined to one type of boiler, because in another boiler the relations may be somewhat different.

Perhaps the best way to compare costs is on the basis of the number of gallons of oil which are equivalent to a ton of coal. This will eliminate the variable of prices, and the figures presented can be used as a comparison in any locality where the prices of oil and coal are known. The Bureau of Public Roads of the Department of Agriculture investigated the comparative consumptions of coal and oil with small round boilers such as would be found in an average dwelling house.

From these investigations it was learned that 1 short ton of coal is the equivalent of from about 150 to 175 gallons of oil fuel.

The particular sizes and types of boiler for which these comparisons are drawn are such as would be found in the homes of 6 to 10 rooms and therefore represent conditions obtaining in a large percentage of installations. For such installations, therefore, 150 to 175 gallons of oil may be considered as approximately the equivalent of a short ton of coal.

Such a comparison involves only the fuel cost. A true comparison should include many more items. Some of these items can be stated as follows:

With the oil burner there is an investment which must be considered. The cost of the burner installation may be several hundred dollars and interest and depreciation must be charged against the oil burner. On a small installation these fixed charges alone may represent a large percentage of the cost of the fuel. The cost of the auxiliary power must be added, that is, the gas or electricity or both, depending on the type of burner. This cost generally runs from $3 to $5 per month during the heating season. Moreover, after the free-service period, which generally is one year, service-call charges must be reckoned with, although with good burners, properly installed, this should be small.

As against this the principal arguments advanced for the oil burner are its convenience, comfort, and cleanliness. The employment of an attendant for an oil-burning heating plant in the home is unnecessary. As to cleanliness, it is maintained that with the use of oil burners the cost of cleaning and redecorating is greatly lessened. As compared with soft coal this is undoubtedly true, but an oil burner out of adjustment may produce a quantity of soot that will permeate the house in a very short time.

In the average-sized house, where no great saving in furnace attendance can be shown, the cost of heating with oil is almost invariably greater than the cost of heating with coal—all things considered.

CARE OF BURNER

As in the case of any other mechanism, a little care in the following of certain directions that are given in printed form by the manufacturers or agents of the burner will be well repaid. Oil-burner men are subject to service calls for minor ailments easily remedied by the owner if just a little attention were devoted to the burner. Accidental dropping of a drip bucket or the blowing of a fuse account for many service calls, and these could easily be remedied by the owner.

Instructions as to oiling and general care of the burner should be followed strictly. Various agents have different plans for the care of the burner. Some periodically overhaul and oil the moving parts at a nominal price, and thus each heating season is begun with a plant in good condition.

In the summer, the temperature of the basement is generally somewhat lower than the outside temperature and there is apt to be a general dampness which tends to corrode parts of the burner. As far as is feasible the removal of motors and other parts likely to be injured is recommended.

It is well for the owner to refrain from attempting adjustment. The prime requirement for burning oil economically is that the proper proportions of air and fuel shall be admitted to the furnace. This condition is generally provided for by the installation man and more than likely any subsequent attempts on the part of the owner will result in less favorable conditions.

IMPROVEMENTS POSSIBLE WITH EXISTING BOILERS

In most cases of house heating with oil burners, the burner has been installed in a fire box designed to burn coal. In a large percentage of these installations the boilers are not properly designed for the efficient use of oil, either because of insufficient combustion space, or inadequate gas travel or heat-absorbing surface. In general it is not practicable to alter the combustion space by any change in the existing boiler, but in many instances the heating surface of the boiler can be altered in order to effect a considerable fuel saving.

Most heating boilers are built up—that is, they are composed of a number of castings which are bolted one on top of another as shown in Figure 21 or one behind the other, depending upon the form of the boiler.

Tests conducted by the Department of Agriculture on 25-inch round hot-water boilers showed some interesting results as to savings realized by the addition of numbers of sections. The smallest was a four-section boiler consisting of base, fire pot, one intermediate section, and dome. The next larger boiler had two intermediate sections, making a five-section boiler, and the largest was a six-section boiler in which there were three intermediate sections in addition to the other sections.

These tests showed that to achieve the same heating results the five-section boiler required 15 per cent less fuel than the four-section, and the six-section boiler required 25 per cent less fuel than the four-section. Thus it is very often economical to add a section or two to a small boiler before installing an oil burner. Of course, lack of head room sometimes preclude such alterations.

SAFETY

A question of great importance to those considering installing an oil burner is safety. Regardless of other advantages to be obtained from the installation of such a device, no one would have a burner if he did not feel that it was reasonably safe. Some commendable work has been done by the Underwriters' Laboratories[5] wherein various burners have been investigated from the standpoint of safety. The underwriters do not test burners for efficiency. To quote from a pamphlet issued by them:

> Primarily, the questions to be settled are: Will this burner set fire to the building in which it is installed, or is there a possibility of its causing an explosion, or being instrumental in injuring the person giving it the ordinary amount of attention required
>
> Roughly speaking, there are three parts to the work of a complete investigation of any oil-burning equipment. These include a study of the design and construction from blue prints and the actual samples; tests of the samples and an investigation of the field service record.
>
> As one of the important factors in the use of burners of this type is the selection of suitable grades of oil, at least part of the test work is done using the lowest grade of oil which the submittor claims is suitable.
>
> In general, the listing of any oil-burning equipment by Underwriters' Laboratories means that the equipment has been examined and tested, and found to comply with the minimum requirements in effect for its class, and that the manufacturer has agreed to maintain the standard established and to identify the listed product with the marking agreed upon. Particular attention should be paid to the exact form of marking used to designate the listed device as stated on each card and in the regularly published list under the heading of "Marking." The listing of oil burners as standard does not mean that the products listed are necessarily equivalent in quality or merit. Any question with regard to the effect of the installation of an oil burner on insurance rates should be taken up with the company insuring the property or with local authorities having jurisdiction.

In addition to the safety of the burner itself there are to be considered the matters of placing tanks, installation of piping, the burner proper, and in some cases the electric wiring. In handling all of the items the installer should have in mind the National Board of Fire Underwriters' rules and the national electric code.

The underwriters' designation on a burner is looked for when considering the device from the standpoint of a fire hazard, but a burner should not arbitrarily be eliminated because it does not bear such approval. There are undoubtedly many burners not listed by the underwriters which present just as little fire risk as those listed. As a matter of fact, many of the burners have not been submitted to the underwriters for test and still others may be on the waiting list.

It is highly desirable in contemplating the installation of an oil burner to familiarize one's self with the recommendations of these laboratories. Literature has been prepared and is available to the public.

Investigations made by the Department of Agriculture have disclosed the fact that a great number of the oil-burner fires can be traced to faulty installation and adjustment rather than inherent weakness in the burner.

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[5] The Underwriters' Laboratories, Chicago, Ill., maintained by the National Board of Underwriters.

SUMMARY

Investigations of oil burners for home heating by the United States Department of Agriculture indicate that they are well suited to the requirements of many home owners on account of their convenience and ease of heat control if, to obtain these advantages, the prospective purchaser is willing to pay the cost of the change and possibly an increased operating cost. Before deciding whether a change to oil burning is desirable there should be a thorough understanding of the adaptability of the present heating plant to oil burning, of the operating characteristics of different types of oil burners, and of installation and operation costs.

Fuel for oil burners is derived from crude oil after other products have been extracted and is sold in various grades, the proper grade for use in any case being determined by the type of burner in which it is to be used. Great ingenuity has been shown in developing apparatus to burn these oil fuels. One general type, the vaporizing type, secures combustion by allowing the oil to drop on a hot plate by which it is vaporized, after which it is mixed with the air in the chamber and burned. The plate must be heated to start operation and in general these burners are not equipped with automatic control. They require a light oil which costs somewhat more per unit of heat than the heavier grades.

The atomizing types have a motor and other mechanical devices for atomizing the oil and mixing it with air before delivery to the combustion chamber. They are generally equipped with full automatic control, are less exacting as to the type of fuel required, and are less given to smoking and sooting because of better combustion.

Several types of burners now on the market afford good combustion of oil fuels, and tests have shown that there is no material difference in the efficiency of the better makes. Any burner which will burn the fuel without giving off soot or smoke and does not require a great excess of air may be considered as satisfactory with regard to combustion.

Oil burners are being applied to all of the types of heating plants commonly used for home heating. If the present plant, when burning coal, does not give sufficient heat very probably an oil burner will not improve this condition.

Safety is of paramount importance in any device to be used in the home and, regardless of any advantages claimed, no one would be justified in installing a burner that is not reasonably safe. The Underwriters' Laboratories have tested and listed many of the burners now manufactured as complying with certain standards of minimum hazard. Burners that have been so tested bear a mark indicating the fact. However, the absence of such marking does not necessarily mean that a burner does not comply with the requirements of the Underwriters' Laboratories since there are on the market a number which have not been submitted for test or which are now on the waiting list.